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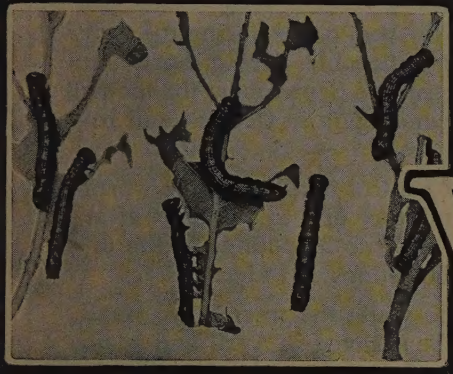
# California Oak Worm



THE LIVE OAK and the valley oak, which are characteristic of the landscape of central California, often are stripped of their leaves by a dark-striped worm which is the young stage of a light-brown moth. Besides stripping the trees of their leaves and making the owner think that they are dead, the worm crawls on lawns, walks, fences, and into houses, swimming pools, etc., becoming a general nuisance.

Two generations of the pest occur during the year. The worms are most noticeable during April and May and again in August and September; the moths, during June and July and again in October and November.

The best method of control is to spray the worm-infested trees with a mixture of 3 to 5 pounds of arsenate of lead paste, or 1½ to 2½ pounds of the dry powder, dissolved in 50 gallons of water.

This should be done while the worms are small. The live oaks should be sprayed in April and again, if necessary, about the 1st of August, when the deciduous oaks are sprayed.

This bulletin describes and illustrates the worm and its work, tells about its habits and natural enemies, and explains the methods of control.

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief
Washington, D. C. February, 1920

# CALIFORNIA OAK WORM.[1]

By H. E. Burke, *Specialist*, and F. B. Herbert, *Scientific Assistant, Forest Insect Investigations.*

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## ECONOMIC IMPORTANCE.

THE most important and characteristic native shade trees of the coast valleys of central California are the live oak[2] and the white or valley oak.[3] As a general rule these splendid trees are healthy and vigorous, but at times they are preyed upon by a number of destructive insects, some of which cause defoliation and give the trees a very unhealthy appearance.

Probably the worst of these from the standpoint of the general public is the California oak worm or moth. This pest not only strips the trees of their leaves, making them worthless for shade or ornament and giving them the appearance of being dead, but it also makes a general nuisance of itself by crawling on sidewalks, lawns, and fences, and into houses, swimming pools, and other places.

It should not be confused with the western oak looper,[4] a true measuring worm, which defoliates oaks similarly in Oregon and Washington.

## HISTORY.

So far as can be determined the oak worm is a native of California. Ever since the days of the first settlement by the white man it has attracted his attention at regular intervals because it occurs in enormous numbers every few years and completely defoliates the oaks. Whenever the pest has escaped its natural enemies

[1] *Phryganidia californica* Pack., family Dioptidae, order Lepidoptera.
[2] *Quercus agrifolia* Nee.
[3] *Quercus lobata* Nee.
[4] *Therina somniaria* Hulst.

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it has become exceedingly abundant and injurious, but when the natural enemies have overtaken it they have so reduced its numbers that for the time being it attracts no attention.

The oaks were badly defoliated by the worms in 1851, 1875, 1895, 1908, 1913, and 1917.

## DISTRIBUTION AND FOOD PLANTS.

The oak worm is most abundant in the San Francisco Bay region, but occurs throughout most of the coast region where the live oak grows, from Sonoma County to Southern California. Besides the live oak and the white oak, the insect also feeds on various other species of native and introduced oaks, the American chestnut,[1] and in some cases on the blue gum.[2]

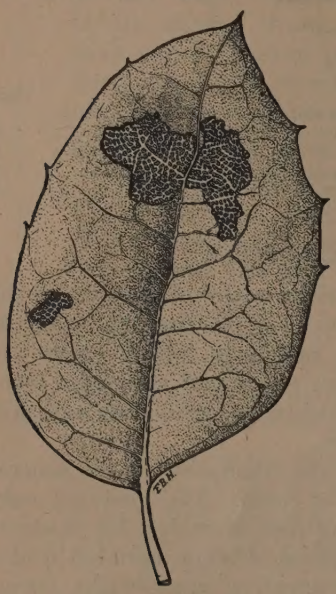

FIG. 1.—Live-oak leaf with upper surface partly eaten by California oak worms in the first stage. Enlarged.

## CHARACTER OF WORK.

The young worms eat the pulp from the surface of the leaf between the netted veins, feeding on either surface but more often on the upper (fig. 1). This causes light brownish, pitted patches on the leaves, which give them a very characteristic appearance. These darken with age, but the work can be distinguished as long as the leaves remain. The older worms feed on the edges of the leaves, eating everything down to the main ribs. (See title page.) During epidemic infestations practically every green part of the foliage is gone and the deciduous trees are as leafless as in winter. The skeletonized leaves of the white oak soon fall, but those of the live oak remain on the tree for some time.

The worst of the havoc is over about the first of September and then the worms begin to crawl. Some are seeking fresh food and others places for transforming to chrysalids. This moving habit makes them much more of a nuisance to man than the defoliation of his trees. They get into houses and hammocks, and on lawns, sidewalks, and fences. One can not enjoy the shade because of myriads

[1] *Castanea dentata.* [2] *Eucalyptus globulus.*

of crawling, squirming worms, and when one has become thoroughly hot and disgusted and decides to take a plunge in the tank or "old swimmin' hole" it will probably be found that the worms are there also and that even a swim is very unsatisfactory during the worm season.

## THE INSECT DESCRIBED.

Like all moths, the oak worm has four distinct forms, of which the worm is the feeding and growing form. As soon as the worms are full grown they change into chrysalids, the resting form, from which emerge the moths that are the parents of the race. These mate and the females lay eggs which hatch into the next generation of worms.

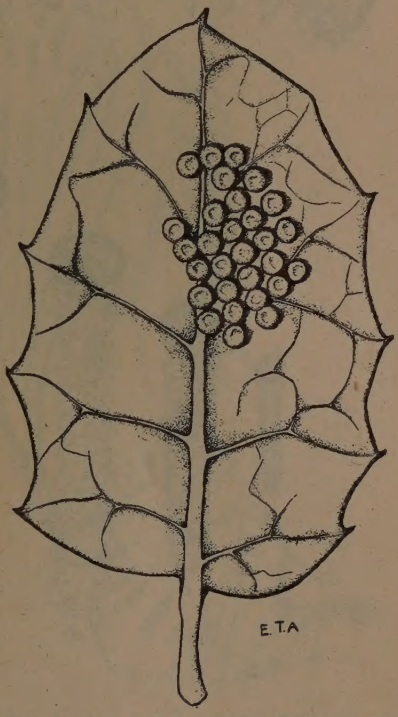


FIG. 2.—Group of eggs of the California oak worm on live-oak leaf. Enlarged.

### THE EGG.

When first laid, the egg (fig. 2) is almost white, nearly spherical, and about one twenty-fifth of an inch in diameter. As the young worm develops inside, the color changes to lemon yellow, brownish red, chocolate brown, and finally to a mottled pinkish gray. The egg also becomes flattened with age and has a slight depression in the outer or topmost end.

### THE WORM.

When first hatched, the worm (fig. 3) is light colored, sparsely covered with long hairs, and its head is enormous in proportion to the body. It soon acquires some dark spots and dark reddish stripes and after going through five stages and becoming full grown it usually is almost black and nearly hairless. Numerous individuals, however, do not acquire the dark color but retain the lighter tints of the younger stages. The body becomes wider and longer until it is in proportion to the head. When newly hatched the worm is about one-tenth of an inch long and when full-grown about 1 inch.

### THE CHRYSALIS.

The chrysalis, a form (fig. 4) which looks something like a mummy, is about one-half an inch long by one-sixth of an inch broad. It varies from whitish to yellow in color and has a number of black lines and splotches upon it.

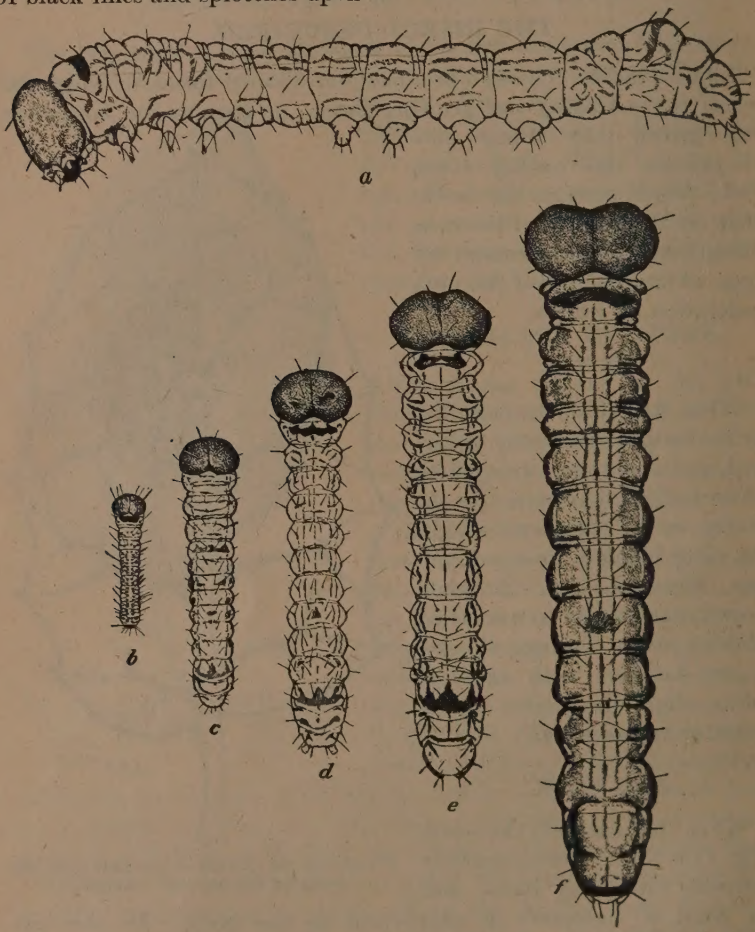


FIG. 3.—The California oak worm: *a*, Side view of full-grown worm of fourth stage about to change to fifth; *b*, newly hatched worm of first stage; *c*, *d*, *e*, *f*, newly changed worms of second, third, fourth, and fifth stages. Enlarged. When newly hatched or changed the head is wider than the body, but when each stage has become full grown the body is as wide as the head and has grown proportionately in length.

### THE MOTH.

The moth (fig. 5) is light brown with rather prominent dark veins. The body is about one-half an inch long and the wings spread about

1¼ inches. The males have faint yellowish patches near the center of each forewing, and their antennæ, or feelers, are broader and more feathery.

## LIFE HISTORY AND HABITS.

The eggs which start the new generations of worms are laid by the female moth in various places—on the leaves of the oaks and many other trees, on the bark of the trunks, on the grass under the trees, and seemingly on anything that she happens to fly against or crawl upon. Only those eggs laid on the oak, chestnut, and eucalyptus leaves, however, produce worms that have a chance to mature. The worms from the eggs laid in other places are without suitable food and must starve. And even the oaks are very often disappointing. The leaves of the deciduous species usually fall off in the autumn and the worms hatched from the eggs laid on them by the fall generation of moths starve on the ground. Sometimes, however, as in the fall of 1917, the old leaves do not fall until the new ones come out and then the worms on them winter over in good condition.

FIG. 4.—The chrysalis or resting stage of the California oak worm. Enlarged.

The great majority of the eggs laid on the leaves are laid in more or less regular rows in groups of from 2 to 40 on the under surface of the leaf (fig. 2). They hatch in from 10 to 15 days in the summer time and from that to 4 months in the winter time.

Soon after it hatches, the young worm takes its first meal by eating the eggshell. It then begins to feed on the leaf, usually on the upper surface, eating out the pulp between the veins (fig. 1). During the early stages a number remain together, and their feeding causes large patches of pitted surface to appear. In the later stages

the worms scatter and, feeding on the edges of the leaves, eat them down to the larger veins and midribs (see title page).

While it is growing the worm changes its skin from three to six times, going through from four to seven stages (fig. 3). The normal number is five, and nine-tenths of the worms go through that number of stages before they change to the chrysalis. During each successive stage the worm feeds a while, gets larger, rests, and then goes through the transformation to the next larger stage.

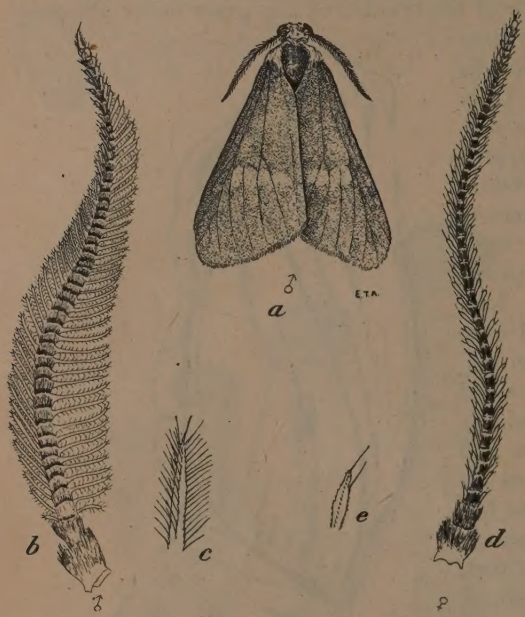


FIG. 5.—The moth or parent stage of the California oak worm: *a*, Male, enlarged (the female has no light spots on the wings and the antennæ are slender); *b*, antenna of male, more enlarged; *c*, bristle from same, much enlarged; *d*, antenna of female, enlarged; *e*, bristle from same, much enlarged.

Upon becoming full grown it crawls off to some protected place, such as the trunk of a tree, a fence, or a bush, and transforms to the chrysalis.

In about two weeks a moth emerges from each healthy chrysalis and, if a male, seeks a female and mates. The female then lays its eggs on an oak leaf or almost anything that happens to be near. Eggs have hatched on rye grass, marsh mallow, china lettuce, elm, and cypress bark, but the young worms died soon after hatching.

## SEASONAL HISTORY.

Two generations of the oak worm occur each year. From eggs laid in October and November worms hatch in November, December, January, February, and even March. These become full grown in May and June and transform to chrysalids, from which the moths issue about two weeks later. The greatest emergence is about the last of June. Mating soon takes place and the eggs of the second or summer generation are laid. These hatch in about two weeks, the majority hatching about the middle of July, and the worms become

full grown in September and October, when they form their chrysalids and issue as moths about two weeks later. Mating soon takes place and the eggs of the winter generation are laid. Most of the moths from the summer generation of worms fly in November, and most of those from the winter generation fly in June.

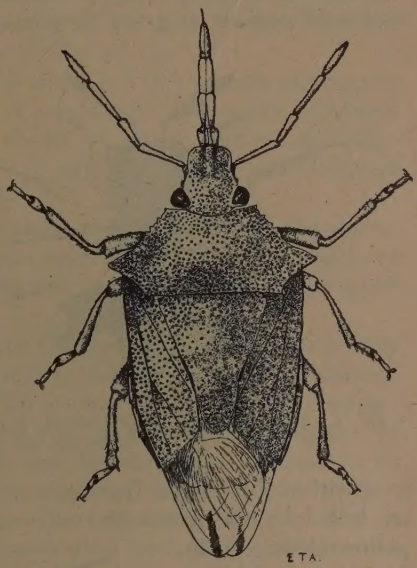

FIG. 6.—The spined soldier bug, an enemy of the oak worm during the egg, worm, and chrysalid stages. Much enlarged.

## CONDITIONS FAVORABLE TO OUTBREAKS.

As the deciduous oaks usually shed their leaves before the new ones come out in the spring, most of the worms of the winter generation living on them starve, and only those on the live oak live over to perpetuate the species. Without the live oak, therefore, the insect would become extinct, and for this reason localities with deciduous oaks and without live oaks have nothing to fear from it.

So far as can be determined at present, the main condition favorable to an outbreak in the live-oak territory is the lack of natural enemies, brought about by starvation caused by the scarcity of the oak worm, which they have almost exterminated. When the natural enemies have reduced the worm to its lowest ebb, many of the natural enemies die from lack of food, and the worms increase again and become epidemic. This condition exists until the few parasites that are left have time to multiply and their descendants increase to the maximum; then down goes the worm to stay until the enemies starve and become scarce again.

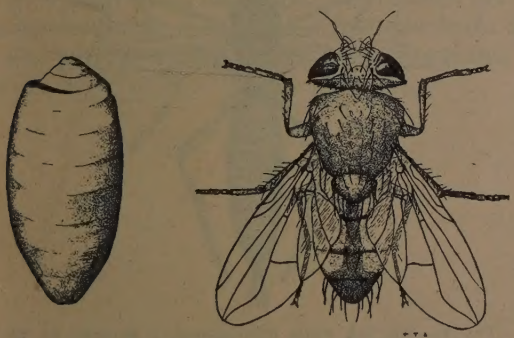

FIG. 7.—A fly parasitic on the full-grown California oak worm.

## NATURAL ENEMIES.

### INSECT PREDATORS AND PARASITES.

Thus, one of the principal reasons why the oak worm has a succession of periods of great abundance followed by periods of great scarcity is that its insect foes concentrate in deadly attack as soon as the worm does become abundant. The eggs, all stages of the worms, and the chrysalids are punctured and sucked dry by the spined soldier bug[1] (fig. 6); the larger worms are destroyed by a small grayish fly[2] (fig. 7) which lives within their bodies during its maggot stage; and the chrysalids are killed by the grubs of two wasplike parasites, the black and yellow chalcid[3] (fig. 8) and the oak worm ichneumonid[4] (fig. 9), which feed on the internal organs.

FIG. 8.—The black and yellow chalcid, a parasite on the chrysalis of the California oak worm.

### BACTERIAL DISEASE.

Another important natural enemy of the oak worm is an undetermined disease supposed to be bacterial in origin. Often when the worms occur in the greatest numbers the disease appears among them and kills thousands. Worms killed by it become dark and flaccid and hang limply from twigs, branches, fences, houses, and wires.

FIG. 9.—The oak worm ichneumonid, a parasite on the chrysalis of the California oak worm.

[1] *Podisus maculiventris* Say.
[2] *Thryptocera flavipes* Coq.
[3] *Chalcis abiesiae* Girault.
[4] *Itoplectis behrensi* (Cress.).

## METHODS OF CONTROL.

During that period of this never-ending warfare at which the worm is at its greatest increase, the trees suffer, and man must join the fight if he would save the appearance of his trees for the year and prevent the nuisance of a plague of the worms.

The best spray to use against the worm is 3 to 5 pounds of arsenate of lead paste, or 1½ to 2½ pounds of arsenate of lead in dry powdered form, dissolved in 50 gallons of water. A power sprayer should be used, the mixture should be kept well agitated, and the entire foliage should be covered with a fine mist.

To get the best results the trees should be sprayed while the worms are in the younger stages. They are more easily killed then and have done very little damage. Do not wait until the trees are stripped and the worms are full grown.

If the moths are abundant about the trees in June and early July a heavy crop of worms probably will appear during the late summer, with the resulting leafless trees. To prevent this, spray both live and deciduous oaks during the last of July or the first of August. If the moths are common in October and November the worms will do the most damage to the live oaks in April and May. To prevent this, spray during March and April. The important thing is to wait until most of the eggs of the generation have hatched and then to spray at once while the worms are small.

If only one spraying is to be given, spraying the live oaks in the spring is the better time, for, under the usual California rainless summer conditions, the poison will remain on the leaves until September and will catch both generations of worms.

As a usual thing the property owner will get better results for less money by hiring a commercial tree sprayer to do the work. Choose a tree sprayer by the reputation he has made, and then follow his advice.

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